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ON
THE PHOSPHATES
AND
ARSENIATES.

BY JOHN DALTON,

D.C.L., F.R.S., &c.

MANCHESTER:

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1840.



ON THE PHOSPHATES.

I published a Table on the absorption of Gases by Water and other Liquids, in 1803, in the 1st volume of the *new series* of the Manchester Memoirs.

Hydrogen...1 ; Water, 6.5.

Azote 4.2; Nitrous gas, 9.7 ; Nitrous oxide, 13.9 ; Nitric acid, 15.2.

Carbone...4.3 ; Carbonic oxide, 9.8 ; Carbonic acid, 15.3 ; Olefiant gas, 5.3.

Oxygen...5.5 ; Carburetted Hydrogen, 6.3 ; Ether, 9.6 ; Alcohol, 15.1.

Phosphorus 7.2 ; Phosphuretted Hydrogen, 8.2.

Sulphur...14.4 ; Sulphuretted Hydrogen, 15.4.

Of which Nitric Acid, Ether and Alcohol have been modified as succeeding discoveries have determined ; but the rest have been substantially realized.

In 1805, I wrote an Essay on “ Phosphoric Acid, and the Salts denominated Phosphates.” It was printed in 1817, in the 3rd vol. *new series*, and I then had the results of Berzelius, Dr. Thomson, and M. Dulong on the subject. Berzelius obtained 50.8 Phosphoric Acid and 49.2 of Lime ; and my own results were 49 Acid and 51 Lime. Saturated with Lime, the Phosphate of Soda left 14 of Soda in the liquor, so that in reality it was a *Biphosphate of Soda*.

On the publication of the 2nd part of my Chemistry, in the year 1810, I adopted 10 for Phosphorus, and the number 21 for Arsenic, and the number 7 for Oxygen, and the number 8 for Water; also the number 28 for Soda, and the number 42 for Potash, and the number 24 for Lime. These numbers I still continue in 1840, not having a material alteration in them.*

Dr. Thomson has been a strenuous defender till lately, of the doctrine of 1 atom of Phosphorus for 2 of Oxygen in Phosphoric acid, vol. 2, page 44, in his Annals of Philosophy. He, however, makes it 1 of Phosphorus and 3 of Oxygen, in the Annals, vol. 4, page 84, 1814.

Sir Humphrey Davy has 45 Phosphorus to 15 of Oxygen in Hypophosphorous acid; in Phosphorous acid 45 to 30; in Phosphoric acid 45 to 60: one of the most perfect specimens of analytic research. Annals 13, page 210—1819. So I think. Dr. Thomson maintains the same in vol. 15 Annals, page 228; also, vol. 16, page 20, 1820.

In 1825, in the first principles of Chemistry, Dr. Thomson has it 1 Phosphorus to 2 Oxygen = 3.5.

In 1831, in his 7th edition of Chemistry, Dr. Thomson prefaces his account of Phosphoric acid: "There cannot be the least doubt that the atomic weight of Phosphoric acid is 4.5; or at least approaching exceedingly near it." This is approach-

* Phosphorus was 9, and Lime 23, in the 1st Edition of my Chemistry in 1808.

ing to 1 Phosphorus and 3 Oxygen of Berzelius :
 $\ddot{\text{P}} \text{Na}^2$ (120.11); whereas Professor Graham has
 it $\ddot{\text{P}} \text{Na}^2$ (136.14.) (Berzelius, Paris Ed. 1835.)

An excellent paper of Dumas, in 1826, is given in the *Annales de Chimie et de Physique*, vol. 31. He describes the Gas given (*protophosphoré*) as obtained from four different materials; from Phosphorous Acid, from the Acid Phosphatique, from the Hypophosphorous Acid, and from the Phosphate of Lime, all of the same kind. It is of the specific gravity of 1.214—one volume takes 2 of Oxygen to form Phosphoric Acid and Water; and one volume takes $1\frac{1}{2}$ to form Phosphorous Acid and Water, as Dr. Thomson and myself have found it, as well as Dumas.

On the supposition that Phosphorus and Hydrogen is 1 atom to 1, (which is always to be advanced first,) it comes out very remarkably, the one Hydrogen is to admit the 1 Oxygen to form 1 of Water, and the one of Phosphorus is to admit 2 of Oxygen to form Phosphoric Acid: also with $1\frac{1}{2}$, of Oxygen, to form Phosphorous Acid, and Water. For, 1.214 (1 vol. Phos. hyd.) is to 2.222 (2 vol. Oxygen,) nearly as the specific gravities of the two Gases.

I make 1 Hydrogen

10 Phosphorus

1 vol. 11 Phosphuretted Hydrogen = 1.214 Dumas.

2 vol. — Oxygen = 2.222 Thomson

I question whether it is in the nature of such experiments to come nearer than $\frac{11}{12}$ or $\frac{12}{22}$.

The burning of *hydrogène perphosphoré* seems to Dumas, inexplicable.

“ *Je ne me suis point dissimulé les objections qui se présentent contre ces conclusions.*” I think he will be glad to find that they are only *quasi* carbonates. “ *Mais tous ces résultats étaient devenus problématiques par suite des travaux plus récents de MM. Dalton, Thomson and Vauquelin.*”

SIMPLE PHOSPHATE OF SODA.

Simple Phosphoric Acid is 1 atom of Phosphorus and 2 of Oxygen, namely 10 for the Phosphorus and $2 \times 7 = 14$ for the Oxygen; it is in reality equal to the atom of Lime or nearly so; that is, 24. Soda I designate by 28.—(See Plate 1, 2 and 3.)



24 } Simple Phosphate of Soda.—This is the
28 } subphosphate of Soda of Prof. Graham. 52

48 } Biphosphate of Soda.—This is the phos-
28 } phate of Soda of others, and its two
16 } atoms of Water (represented by 16) sub-
ject to a red heat.....92


28 }
24 } Subphosphate of Soda.—This is the sub-
28 } phosphate of the author.....80

Simple Phosphate of Soda.—I took a quantity of Biphosphate of soda, and added to it, as much or more soda as is in the Biphosphate. This I suffered to crystallize, and the hard crystals were dissolved

PHOSPHATES.



Phosphoric Acid  24
Soda. (1)  28 *Simple phosphate of Soda.*

(2)  24
 28 *Biphosphate of Soda.*
 24


(3)  28
 24 *Subphosphate of Soda.*
 28

Discovered in 1813

ARSENIATES.

Arsenic Acid  35
Soda (4)  28 *Arseniate of Soda*

(5)  35
 28 *Biarseniate of Soda*
 35

(6)  28
 35 *Subarseniate of Soda*
 28

Discovered in 1839.

in water. This is the Subphosphate of Professor Graham. For adding as much or more soda as is in the Biphosphate (as I call it) reduces to the Subphosphate (as he calls it); only making *two* atoms instead of *one*. I shall transcribe the whole paragraph.

“ If to a solution of the Biphosphate we add as much more Caustic Soda as is in the solution, we reduce the salt to a *simple phosphate*, or one atom to one ; and this is the salt that should be used in most cases as a chemical agent in the analysis of metallic and other salts. It is more soluble than the Biphosphate; it crystallizes in very fine needle shaped crystals, in a liquid of 1.086 specific gravity; whereas those of the Biphosphate are rhomboidal, and the liquid is 1.032 specific gravity.” (3 vol. *new series*, page 12, Manchester Memoirs, 1819.)

Another way is to procure the Triphosphate of Lime ; this will be done by letting down the Superphosphate of Lime by Lime-water, till it becomes a Triphosphate of Lime. This will be easily done, by adding two, three, &c., or more times the Lime-water, till there falls a sediment. Then pour off the clear liquor, which will be Triphosphate of the specific gravity of 1.004 :—Then carefully measuring the Lime-water, till *two* times the measure of the Triphosphate is exhibited, there will be three atoms of Phosphoric Acid to three atoms of Lime mixed together, that is atom to atom. There will not be one particle left of Lime, or of Phosphoric Acid.

Professor Graham says, 28.83 grains of the simple Phosphate of Soda (or the subphosphate, as he

calls it,) loses 12.05 of water, by a sand-bath heat; that is, 55.2 per cent; and in another experiment 56.05 is the water per cent. Taking the mean...

If 44.5 Salt : 55.5 Water :: 52 Salt : 64 Water,* = 8 atoms. I say if 46.1 Salt : 53.9 Water :: 52 Salt : 61 Water, = $7\frac{5}{8}$ atoms, or 8 atoms. This is exactly as any atomic number will afford. The *excellence* is in the experiment of Professor Graham; the *theory* is defective; it is not 23 or 24 atoms of Water but 8 atoms, that is *one-third* part of the number.

Professor Graham assumes the number 71.5 (Berzelius' number) for Phosphoric Acid, instead of 24, (my number.) Berzelius has 24 atoms of Water. Professor Graham hesitates whether 23 or 24 atoms are better. I do not believe that ever 23 or 24 atoms of Water are around any other atom, either simple or compound. It is limited to 12 or 16 atoms in a crystal, at the most. I can collect 12 balls around one ball of the same magnitude, but no more.

Three atoms of mine is *one* of Berzelius' ($1\frac{1}{2}$ is rejected by Professor Graham.)—Hence there is 24 atoms instead of 8, as will be seen by his, (Berzelius') remarks on Arseniates of Soda.

THE BIPHOSPHATE OF SODA.

The Biphosphate of Soda (Phosphate of Soda of others,) has two atoms of Phosphoric Acid, and

* We shall see whether a simple number (24) or a compound and fractional number (71.5 which is virtually *three* times the number, 72,) will answer best. They both refer to the standard (1) which is hydrogen.

one of Soda, 76, to two of Water essential to their existence at a red heat, 16 ; namely 92. There is attached to these 20 atoms of Water in a cold temperature, and preserved in a stopped bottle, but $\frac{8}{20}$ of these fly off, exposed to the atmosphere, and $\frac{12}{20}$ remain. Pulverized and exposed for a week, it loses 64 parts of Water, and leaves 96 parts.*

This is all it loses (64 parts) at a temperature below 90°.

48 Phosphoric Acid.

28 Soda.

16 Two atoms of Water.†

92

‡160 = 20 atoms of Water.

252 Whole quantity of Salt in a crystal.

252) 92 (.365 Salt and Water in the Biphosphate
at a red heat.

252)160 (.635 Water expelled from the Biphosphate
before a red heat.

1.000

* It is remarkable, if fully crystallized, that the Salt in three or four days, when pounded, and sifted, and laid on a flat surface, exposed to the air, is reduced from 252 to 188 parts. It never goes below. If the 188 parts be reduced by heating, they will gradually recover Water in a few days, till it regains 188 parts.

† Two atoms of Water are united, to 48 of Phosphoric Acid, and 28 of Soda, at a red heat. This is not strange ; I discovered in 1809, that *hydrate of Lime* may be heated *red hot*, before the Water is detached from the Lime. One of liquid Sulphuric Acid and two of Water, or one of *Anhydrous* and three of Water, form the *glacial* Sulphuric Acid. I used formerly to keep it in a *frozen state*, from November to April ; there is no danger in freezing it in a bottle, as it *contracts* in freezing.

‡ According to Dr. Clark's calculation, 92 loses 165 = 20 + water.

According to Prof. Graham's do. 92 loses 156 = 20 — water.

According to Dr. Dalton's do. 92 loses 160 = 20 . . . water.

It is well known that the Biphosphate of Soda and Water consists of 36 or 37 Biphosphate of Soda, and 64 or 63 Water, expelled below a red heat in 100 parts. Dr. Clark has confirmed it, in Dr. Brewster's Journal of Science, vol. 7, page 302.

It will be remembered that Dr. Clark was the discoverer of the Pyrophosphates, and has written a very excellent treatise on the subject.—(See Dr. Brewster's vol. 7, page 302, of the Edinburgh Journal of Science.)

Dr. Clark determined that the Pyrophosphates constituted a new class of Salts. He finds the Pyrophosphates of Soda consist of

“ Water expelled by the sand bath.....40.63

Water expelled by a red heat—.09

Dry Pyrophosphate of Soda59.28

100.—”

Now 59.28 dry Salt : 40.72 Water (including the whole quantity of Water) :: 92 dry Salt : 64— = 8 atoms of Water, as in the *Pyrophosphate of Soda*. And in the former case as 44.5 Salt : 55.5 Water :: 52 Salt : 64 Water = 8 atoms, as in the *simple Phosphate of Soda*.

Dr. Clark describes also a “ *New Phosphate of Soda*,” formed about 90° of heat ; this is the *old* Phosphate of Soda suffered to crystallize in 90° of heat.

It has $\frac{12}{20}$ of the Water about it, and suffers as a loss, $\frac{8}{20}$ below 90°, from the fully crystallized Salt.

“ Water expelled by the sand bath	16.303
Water expelled by a red heat	1.186
Dry Pyrophosphate of Soda	16.741”

As 16.741 dry Salt : 17.489 Water :: 92 dry Salt :
96 Water; that is, equal to 12 atoms of Water
for 2 atoms of the Salt.

Stromeyer was the first in 1830, (*Annals de Physique et de Chimie*,) who performed the analysis of the Pyrophosphates and the Phosphates in a very superior manner. They had hitherto been neglected or considered of the same constitution ; but he discovered that they had essential differences.

They are neutralized by different quantities of bases.

“ The Phosphoric Acid	16,545
Oxide of Silver	83.455
	<hr/>
	100.—
The Pyrophosphoric Acid	24.61
Oxide of Silver	75.39
	<hr/>
	100.—”

It will be seen that the atoms of Phosphoric and Pyrophosphoric Acid are about as 24 : 32.

I have tried the oxides of Quicksilver, Silver, Lead, &c. The Phosphoric Acid throws down the oxides of Silver, &c., *unaccompanied* with any Water ; the

Pyrophosphoric throws down the oxides of Silver, &c. *accompanied* with water, and is *three* times as long in falling as the other : notwithstanding the oxides of Silver, &c., are the same, or no way different by reduction, in the quantity of Water they may have.

SUPPLEMENT.

After I had written my paper on the Phosphates, I discovered a new law of the combinations of water with that class of Salts which I apprehend will be found availing.

I was struck with a remark that Dr. Clark makes ; “ I repeat, however, that the consideration of the Pyrophosphates of Soda must be decided by a more extended examination (particularly of the effect of heat on Salts,) than has yet been undertaken.”

I apprehend that the Water goes off by *twos* at a time, till it comes to two at last, (the 16 belongs to the $76 = 92$ finally).

The interval is $70^{\circ} \pm$ of temperature ; that is 70° before going into a *solid* state from a *liquid* state.

The crystallized Phosphate of Soda is not very easily to be broken, when taken out of a close stopped bottle in that state ; though it loses $\frac{8}{20}$ parts of the Water when left in a free state exposed to the atmosphere, in two or three days if pulverized, &c.

It then is in a crystallized state, and is much less transparent than before.

When taken in this last crystalline state, that is $\frac{12}{20}$ of the Water remaining, it melts about 90° Fahrenheit, and it assumes a liquid form, like Water, till I find it gradually approaches to a solid form at 160° by losing *two* atoms of Water; then it assumes a liquid form, by a rise of temperature, and in like manner loses *two* atoms of Water, till it approaches to a solid form at 230° ; then, *two* atoms of Water go off, and it becomes a solid at 300° ; and so on to 370° , 440° , and 510° , &c.

It will be exhibited more in detail in the following form :—

20° to 90° Solid form. *Phosphoric Acid*.
 90° to 160° , it becomes liquid; drawing to a solid form. *Phosphoric Acid*.
 160° to 230° , solid, becoming liquid; then drawing to a solid form. *Phosphoric Acid*.
 230° to 300° , solid, becoming liquid; then drawing to a solid form. *Phosphoric Acid*.
 300° to 370° , solid, becoming liquid; then drawing to a solid form. *Phosphoric Acid*.
 370° to 440° , solid, becoming liquid; then drawing to a solid form. *Pyrophosphoric Acid*.
 440° to 510° ,* solid, becoming liquid; then drawing to a solid form. *Pyrophosphoric Acid*.
 510° to 580° , and upwards. *Pyrophosphoric Acid*.

* At 500° it becomes in some degree insoluble.

I have ascertained that it is *Phosphoric* Acid from the temperature 90° and upwards to 370° ; and it is *Pyrophosphoric* Acid from the temperature 370° and upwards to 580° .

I sent the account of the

Phosphates and *Arseniates*

To the Royal Society,

for their insertion in the Transactions.

They were *rejected*.

CAVENDISH, DAVY, WOLLASTON, and GILBERT,
are no more.

ON THE ARSENIATES.

It is not easy to disentangle the names of the Salts as they are included in the Berzelian Catalogue. I conclude they may be explained as follows :

Arseniates—3 Acids and 2 Bases.

35+35+35 Acids, +28+28, Sodas, (for instance.)

Arseniates-sequi — 3 Acids and 3 Bases ;
(that is, 1 Acid and 1 Base, as I take it.)

Arseniates-per—3 Acids and 5 Bases.

Biarseniates—3 Acids { Na. $\ddot{\text{Ar}}$.
and 1 Base { 28 Base + Acid 35+35+35

In reference to my former paper on Phosphate of Soda, I only know 1 Acid and 1 Base.
and 2 Acid and 1 Base.

My Arseniates are*	35 Acid and 24 Lime, insoluble, alkaline.
— Biarseniates	70 Acid and 24 Lime, soluble, neutral.
— Arseniates	35 Acid and 28 Soda, soluble, alkaline.
— Biarseniates	70 Acid and 28 Soda, soluble, neutral.
— Arseniates	35 Acid and 42 Potash, soluble, alkaline.
— Biarseniates	70 Acid and 42 Potash, soluble, neutral, &c.

Lime is best taken as a carbonate ; pour on Arsenic Acid, till all effervescence ceases ; Lime (24)

* It is evident that the *Subarseniate* of Soda is not the proper name of it. It is the *arseniate* of Soda, as the nitrate of Silver is thrown down in a neutral state by double decomposition. Sometimes Professor Graham calls it *Subarseniate*, and sometimes *arseniate*.

So also the *Subphosphate* of Soda ; the proper name of it is the *Phosphate* of Soda.

and Carbonic Acid ($19\frac{1}{2}$), becomes Lime (24) and Arsenic Acid (35).—Lime is taken in solution when the object is to saturate it. Half the acid is taken when the Lime is thrown down.

The same in barytes, &c.—*See the plate 4, 5, & 6.*

35	}	Arseniate of Soda. This is the subarseniate of Professor Graham	63 weight
28			
35	}	Biarseniate of Soda. There is no other biarseniate but this	98 weight
28			
35	}	Subarseniate of Soda. Of the author, 91 weight.	
28			

Thus it appears that the Arseniates and Phosphates are alike, only it is inserting an atom of Arsenic for an atom of Phosphorus.

ARSENIATE OF SODA.

35	Arsenic Acid.....	per cent.....	27.56	}	49.61
28	Soda.....	——	22.05		
64	Eight atoms of Water			——	50.39
					100*

* I discovered a remarkable circumstance on the Phosphates and Arseniates, perhaps to all the class of salts; it is this,

As the Phosphoric Acid, 24,

Is to the Arsenic Acid, 35,

So is the *solubility* of Phosphate of Soda, 19.6.—Page 255, Line 6.

To the *solubility* of Arseniate of Soda, 28. ————— Line 4.

Professor Graham's Experiment.

The entire Water of the Arseniate of Soda, (the Subarseniate of Professor Graham,) is 50.22 per cent. whilst the whole Arseniate of Soda is 49.75.

Phil. Trans. 1833, page 257.

— If 49.75 dry Salt : 50.22 Water :: 63 dry Salt : 64 — Water = Eight — atoms of Water.

I make it 49.51 dry Salt : 50.31 Water :: 63 dry Salt : 64 + Water. = Eight + atoms of Water, as in the simple Phosphate of Soda.

Professor Graham says, “ the quantity of Water in the Salt, namely 50.22 is not easily reconciled with our best *data* for atomic weights. Adopting the atomic weights of Arsenic given by Berzelius, which I had an opportunity of verifying, a Salt of 24 atomic proportions, corresponds with 50.22
23½ atomic proportions, 50.29
23 atomic proportions, 49.75”

Phil. Trans. 1833, page 258.

Berzelius in his view is right ; it is $3 \times 8 = 24$. But Professor Graham adopts the last number 23 ; it accords better with his (Professor Graham's) view.—Berzelius has *put* 10 per cent. upon Arsenic and Phosphorus, and *taken* 10 per cent. off from the Oxygen (5 atoms instead of 6); the Arsenic and Phosphorus (+), and the Oxygen (—), may be so accommodated that they will agree *moderately* with the circumstances of the case.

BIARSENIATE OF SODA.

The Biarsenate of Soda is 2 atoms of Arsenic Acid, 1 of Soda, and 10 of Water.*

70 two atoms of Arsenic Acid.....	39.33
28 one atom of Soda.....	15.70
80 ten atoms of Water.....	44.97
	<hr/>
	100.

This is the Salt Professor Marx, of Brunswick, and Dr. Clark, of Aberdeen, operated upon, on the paper following the one which I described. Vol. 7, page 309.—Brewster's Journal.

Dr. Clark pitches upon (as Berzelius had done,) 22.226 *Dry Salt* from a certain quantity of Salt and Water, in crystals, dried in a handkerchief, and in blotting paper.

Dry Salt.	Water.
22.226,	18.612, Crystals.
22.226,	17.565, Dried in a handkerchief.
22.226,	16.894, Dried in blotting paper.

Corresponding with this, in my case :

Dry Salt.	Water.	Dry Salt.	Water.
As 55.03 :	44.97 ::	22.226 :	17.823.

Both Professor Marx and Dr. Clark go by Berzelius, he being the standard authority, and his determination is $1\frac{1}{2}$, or 3 times of mine ; taking $1\frac{1}{2}$,

* If the Nitric Acid, boiling hot, is not competent to convert Arsenic into the Biarsenic Acid, I do not know what is.—See Dr. Thomson's Arseniate of Soda.—Annals, 15, 82 page.

it is necessarily 15 the weight of Water as Dr. Clark has it more properly; and 16 as Professor Marx has it.

Dr. Thomson has an excellent experiment on the Arseniate (Biarseniate) of Soda, in his volume 15, of Annals, page 82. I cannot say the same for his analyses.

He has a similar one, page 85, on the Arseniate (Biarseniate) of Potash, which is given below.

BIARSENIATE OF POTASH.

The Biarseniate of Potash is constituted of 2 atoms of Arsenic Acid, 1 atom of Potash, and 1 atom of Water; that is, 70 Arsenic Acid, 42 of Potash, and 8 of water.

	Dr. Dalton.	Dr. Thomson.	Berzelius.
Biarsenic Acid [*] 70 per cent.	58.33	— 65.426	— 63.86
Potash 42	35.00	— 27.074	— 26.16
Water 8	6.67	— 7.5	— 9.98
	120	100.—	100.—

After paying a handsome compliment to Berzelius, Prof. Graham analyses the Arsenic Acid produced by Sulphur, in which he finds the results as under:—

* I have, however, to apologise for a strange mistake I fell into in an account of the *Arsenic Acid*, in my second volume of Chemistry. Of the *Arsenious Acid*, I have full confidence.—Twenty-eight parts of Arsenious Oxide throw down twenty-four parts of Lime. I had no proper *Arsenic Acid* at the time; and, therefore, what I said about it is erroneous, as appears in the present Essay.

	Analysis by Professor Graham.	Theory of Berzelius.	Theory of Dalton.
Arsenic Acid	25.67.....	25.61.....(35)	25.75
Oxide of Lead	74.33.....	74.39.....(97)	74.25
	<hr/> 100.—	<hr/> *100.	<hr/> 100.

In 1814 Berzelius published a general Table of the weights of the atoms of matter.—Annals of Philosophy, vol. 3. p. 362.

In 1816 he publishes another Table of weights, and he continues them.

Why are these 12 to 16 per cent heavier in the article of Arsenic and Phosphorus than in any other bodies? They will accord better with 3 and 5 (6?) per cent Oxygen than with 1 or 2, according to Berzelius. Sulphur, &c., is near the same as in the two tables. This (Sulphur) too will accord better in this new circumstance than with Laugier, in regard to Arsenic. The last mentioned gentleman finds a fine, brilliant, uniform and crystallized compound of Arsenic and Sulphur of 3.2 specific gravity; whereas, Berzelius finds a *dark coloured*, opaque compound from 3.3 to 3.7 specific gravity, evidently more or less abounding with Arsenic, as the uniform compound of 1 atom Arsenic, and 1 atom Sulphur. Laugier and mine accord better.

I believe it will turn out, as Dumas expresses it, “*M.M. Davy et Thomson regardent la proportion*

* Berzelius has calculated this from *Arsenate sesqui-plombique*,
 $\text{Pb}^3 \cdot \ddot{\text{As}}$; when 1 atom and 1 would have done as well.

d'oxygène comme plus forte dans l'acide phosphorique, et assignent à ce nombre un rapporte plus simple, celui de 3 à 6 ou de 1 à 2."

I published a Table of the weights of atoms in 1808, in the first part of my Chemistry, the number were 37 in all; in the second part, in 1810 the number were 87 in all; in the second volume, published in 1827, these were swelled to 126 in all. The lowest Hydrogen was 1, the highest Mercury, 167, in all the three publications: but sundry atoms were changed in the intervals. There were 6 or 7 most material to be known, as they influenced the rest; these were determined by the most rigid accuracy by the late Dr. Turner, in the Philosophical Transactions, 1833. They were all dependent on *Oxygen*, as the fundamental element. In mine, the *Oxygen* was 7; in Berzelius', 8, or 8.01. I take 8 as the standard, and reduce them all to the same level as Dr. Turner does.

	Dr. Dalton's in 1827.	Dr. Turner's in 1833.
Lead.....	102.55.....	103.5
Silver.....	102.55.....	108.
Chlorine	33.14.....	35.42
Barium	68.11.....	68.7
Mercury	198.	202.
Nitrogen	11.43.....	14.15
Sulphur.....	16.	16.09

These were the improvements in the atomic system, from 1827 to 1833.

ADDENDA.

IN 1810, I was solicited by Davy to offer myself as a candidate to the Royal Society, but I declined it. In 1816, I was elected a *Corresponding* Member of the Institute of France, and known in the sequel by M. Biot, who had called upon me at Manchester, on his return from *Unst*, in the Shetland Isles, in his researches upon the Pendulum. I was at Paris in 1822, and was introduced at the French Institute as a *Corresponding* Member, by M. Biot.

I had the happiness to know in Paris, the Marquis de la Place, Berthollet, Gay-Lussac, Thenard, Arago, Cuvier, Brequet, Dulong, Ampere, &c., and was invited, with my two companions,* to receive their hospitalities.

Upon the death of Davy, in 1830, I was introduced as an *Associate* Member of the French Institute.

In 1822, some of my friends proposed me, without my knowledge, as a Candidate to the Royal Society ; I do not know who they were until this present time, but it will be upon record I suppose : I was elected, and paid the usual fee. I was bound

* William Dilworth Crewdson, Esq. Benjamin Dockray, Esq.

in some measure to furnish them with occasional papers. They are,—

- 1 On the Constitution of the Atmosphere, in their Transactions.....1826
- 2 On the Height of the Aurora Borealis from the surface of the earth, particularly one seen in the 29th of March, 1826.....1829
- 3 Sequel to an Essay on the Constitution of the Atmosphere, published in 1826, with some accounts of the Sulphurets of Lime..1837

In 1839, I sent an investigation of the Phosphates and Arseniates, a work which has cost a good deal of time, (in my present state, afflicted with Paralysis) particularly with the ARSENIATES. I do not know what the Society were about to reject it, unless it had been a want of *Chemical* gentlemen on the Committee, for it appears as plain as the *Carbonate of Potash and Soda*. It has been the misfortune that Berzelius has continued it so long ; it may be that Berzelius himself will be the first to adopt it. I have been very willing to avail myself of his discoveries, as my works will bear testimony.

THE END.

I intend to print my Essays in future to be appended to my other publications. Some of them are materially affecting the Atomic system.

- 1 On the Mixture of Sulphate of Magnesia and Biphosphate of Soda.
- 2 On the Mixture of Biphosphate of Soda and Ammonia ;—making Microcosmic Salt.
- 3 *Acid, Base and Water, &c. Solid and liquid in all atoms.*

J. D.

ON MICROCOSMIC SALT.*

Bergman was the first to remark, that “ I am not acquainted with any acid which can endure the fire upon charcoal, except that of the Microcosmic Salt. This salt is neutral, but triple, containing both the volatile and mineral alkali. The Phosphoric Acid saturated with volatile alkali cannot be brought to crystallize, which yet always happens upon the accession of a proper quantity of mineral alkali, and the triple salt, which results from hence is commonly called *Microcosmic Salt*. Upon fusion of the charcoal, this sends forth its volatile alkali ; so that the portion of acid which had been before saturated with it, being now set at liberty, is the better able to exert its effect upon other bodies. I made choice of the mineral alkali well depurated ; the vegetable, on account of its deliquescence, is less proper.”

Bergman was mistaken ; it has no *volatile* alkali, only the *mineral* alkali.

* See Physical and Chemical Essays, by Sir T. Bergman, translated by Dr. Cullen, vol. II. page 82. London, 1788.

M. Anatole Riffault was the first that discovered the fact. See *An. de Chimie* (1822)

He has it—Solid Matter,47475

Liquid Matter, }
Ammonia & Water. }.52525

I have it,

Biphosphoric Acid = 48 } Solid Matter
Soda = 28 }

— 76

Ammonia = 15 } Liquid Matter
Water, 8 atoms = 64 }

— 79

—
155
—

155:76::1:.4903 solid matter

155:79::1:.5097 water, & ammonia.

It seems that the acid 48 and the soda 28 go together, deserting the water and ammonia by heat, and cling to each other, as Biphosphate of Soda, commonly called *Phosphate of Soda*.

ON THE MIXTURE OF SULPHATE OF MAGNESIA
AND THE BIPHOSPHATE OF SODA: NO MAGNESIA
IN THE *SOLID FORM*, BUT IN THE *LIQUID FORM*.

The Sulphate of Magnesia and Biphosphate of Soda are to be taken in the atomic proportions; that is, as I take them, Sulphuric Acid 35, Magnesia $17\frac{1}{2}$; and Biphosphoric Acid 48, and Soda 28, all exempt from water.* I call it by the name of *Biphosphoric Acid*, but it is commonly called *Phosphate of Soda* of the shops.

I have given my reasons in the paper that I have published on the Phosphates and Arseniates.

If equal measures of the Sulphate of Magnesia of the specific gravity of 1.042, and the Biphosphate of Soda of the specific gravity 1.063 (this last warmed a little, about blood heat,) were taken, they will answer the end intended. In the first instance the mixture for a minute will be entirely *liquid*, but in ten minutes it will be gradually *solid*; it may be turned upside down without

* I took the *crystallized* Sulphate and Biphosphate at first going off; but the *water* has nothing to do with the fact. It *accidentally* happens the *water* has *nearly* the same *proportion* as the *simple Salts* without the water.

shedding one drop. A multitude of *small* crystals will be formed so as to retain the water. About 12 atoms of water will be found about 1 crystal (24) of the *simple Phosphoric Acid*, as I have called it, (3 vol. *new series, Manchester Memoirs*, 1819), and now call it the *Phosphoric Acid*, as distinguished from the *Biphosphoric*.

The solid may be squeezed together on a muslin, or paper filtre, till it will not drop, and still retain the 12 atoms of water, which will most of them go off by drying them a few days; but a bright red heat is necessary to get off the last atom of water.

I used 572 grains of 1.042 of Sulphate of Magnesia, and as many grains of 1.063 Biphosphate of Soda, generally speaking; any other proportion will not give the *solid* a maximum, that is, atom to atom.

The *solid* and *liquid* are now to be dealt with.

By squeezing till drop dry the *solid* comes out at an average about,

78 Grains.

60 Grains, dried a day in the open air.

34 Grains, dried a day or two more.

31 Grains, dried a day more.

20 Grains by a *red heat*, long continued.*

* I suppose it had lost four grains by manipulation. It should have been 24.

We have accounted for the 24 grains in the *solid form* below.

We are now to account for the $94\frac{1}{2}$ grains remaining in the *liquid* form.

By dropping Nitrate of Lead into the liquid, it will be found that 35 grains will match the lead, and drop down accordingly, producing 132 Sulphate of Lead.

By pouring Lime Water into the remaining liquor till it ceases to throw down a precipitate, there will be found to require 24 grains of Lime to form Phosphate of Lime, exactly equal to the 24 Phosphoric Acid.

There still remains the *Nitrate of Magnesia*. By pouring in Lime Water there will come down Magnesia, as it is substituted by Lime Water; the Magnesia is a *brownish* white powder, and is seen to flow very slowly down the liquor; it amounts to $17\frac{1}{2}$ Grains.

There remains then the Nitrate of Lime in a neutral state.

ESSAY ON THE QUANTITY OF ACIDS, BASES AND
WATER IN THE DIFFERENT VARIETIES OF SALTS;
WITH A NEW METHOD OF MEASURING THE *WATER*
OF CRYSTALLIZATION, AS WELL AS THE *ACIDS*
AND *BASES*.

READ AT THE LITERARY SOCIETY, OCTOBER 6TH, 1840.

IN 1807 I first published in my system of Chemistry, Part I, the atom of *water*; it was 1 for Hydrogen, and 7 for Oxygen = 8, the relative weight of an atom of water. I have seen no reason for alteration from that time to this, in 1840.

In 1819, M. Thenard succeeded in fastening 2 atoms of Oxygen to 1 of Hydrogen; an instance of uncommon merit, and reflects great credit on his perseverance: I happened to be in Paris, three years after this, and was highly gratified in seeing this experiment performed by himself. This shows that *charcoal* is superior to *hydrogen* in attracting oxygen, as universally shown in books of Chemistry.

It will be seen in the 2 vol. of my Chemistry, published in 1827, that I have adopted

35 for Sulphuric Acid,
 45 for Nitric Acid,
 23 or rather 24, Phosphoric Acid,
 19.4 Carbonic Acid,
 31.8 Oxalic Acid,
 17 or $17\frac{1}{2}$ Magnesia,
 42 Potash,
 28 Soda,
 24 Lime, &c. &c.

The *acids* and *bases* are tolerably well known; but the *water* is susceptible of great variation, from exposing them to heat and cold.

Since the atomic theory was discovered, various authors have given the atomic weights; some in 100 weights of the salts, and others in the acknowledged weights of the atoms. Amongst others, Dr. Thomson, Dr. Henry, Dr. Wollaston, &c. M. Gay-Lussac, Thenard, Dumas, &c., amongst the French; and Berzelius, Mitcherlish, &c. in Sweden

and Germany. Some have succeeded better than others ; and it is my present duty to remark on these authors.

Most of the salts contain *water* ; certain degrees of heat drive off, more or less of the waters. Thus *Sulphate of Magnesia* contains 6 atoms of *water*, at 64° of temperature ; it loses about 1 atom of water for 45° or 50° of temperature by Fahrenheit ; it loses the whole, or 6 atoms of water, by 300° or 400° of heat, and does not gain it again for some days.

Bergman, who was an excellent chemist in the former part of last century, and before atomic numbers appeared, had the merit of ascertaining that *water* constituted 48 per cent of *Sulphate of Magnesia*, which is the very number I maintain.

Dr. Henry states the number 44 per cent of water in Sulphate of Magnesia, in 1810 ; but it was probably in the summer season when he made his experiments ; he observes, it is nearly half the weight of the salt.

Mr. Kirwan states the water of crystallization to be 53,75 per cent in 100 grains, which *Dr. Henry* believes is a little above the truth.

It may not be amiss to give a list of a few of the authors who have given their respective opinions on the subject of *Water* in the *Sulphate of Magnesia*, to show the diversity of opinion.

Bergman. 1783	52	Sulphate of Magnesia	48	Water=6	atoms
Kirwan 1800	46.25		53.75 . . .	=7—	atoms
Henry 1810	56		44	=5½	atoms
Dalton. 1810	60		40	=5	atoms
Henry 1815	50		50	=6 +	atoms
Gay-Lussac. 1820	48.57		51.43 . . .	=7—	atoms
Thomson. . . 1825	48.57		51.43 . . .	=7—	atoms
*Henry 1823, 1829	48.57		51.43 . . .	=7—	atoms
Phillips 1824, 1836	46.4		53.6 . . .	=7—	atoms
Berzelius . . . 1835	49.10		50.90 . . .	=6 +	atoms
Dalton 1840	52		48	6	atoms

Generally speaking, there is *one* Acid to *one* Base, and there are a *number* of atoms of water, from one to twelve atoms, or more ; there are other salts which are destitute of water, and have nothing but an Acid and a Base.

* There is a curious mistake in regard to the late Dr. Henry and M. Gay-Lussac.—In 1820, Tome 13, page 308, M. Gay-Lussac states, “Le Dr. Wollaston, dans son Memoire sur les equivalens chimique, avoit fixé, d’apres les experiencé du Dr. Henry, le nombres equivalent, ou le poid de l’atome de la Magnesia à 24.6 et la quantitie d’eau dans le sulphate de la Magnesia crystallisé à 51.527 pour cent, ou 7 atoms, &c.” He goes on, &c. and finds the means of three experiments to give 51.43 for the loss per cent.

I never understood that Dr. Henry found 51.43 water in Sulphate of Magnesia; on the contrary, he quotes this (51.43) as Gay-Lussac’s experiment, and not as his own, in two or three later Editions.

It is probable that M. Gay-Lussac has confounded *Mr. Kirwan’s* for *Dr. Henry’s* experiments.

Dr. Wollaston, in 1814, has given in the Philosophical Transactions, four salts, with the atoms of water to them, viz.—

Sulphate of Copper, . . with 5 atoms of water,
 Sulphate of Iron, with 8 atoms of water,
 Sulphate of Zinc, with 7 atoms of water,
 Sulphate of Magnesia, with 7 atoms of water.

One or two of these are wrong ; but it is probable he has borrowed them from other quarters, and he is generally correct in other particulars.

Seven atoms of water are of rare occurrence as joined to a particular atom of salt. I have seldom or never met with it.

The new method of ascertaining the quantity of *water* in the salts is now to be discussed : I have a bottle with a stopper, which just contains 572 grains of pure water,* when the stopper is put in, and wiped clean and dry, at the temperature of 60° of Fahrenheit. A graduated tube or jar is necessary, of five or six inches long, and one quarter of an inch in diameter, to measure *exactly to a grain* of water. A platina wire is appended to the neck of the bottle, so as to be weighed more conveniently.

* Not material the *quantity* of water it contains, be it more or less.

An *ounce*, more or less, is to be weighed of any salt ; it is then to be put into the bottle, capable of containing 572 grains of pure water, (the water having been carefully transferred into another glass vessel of more ample dimensions,) and the salt dissolved, and carefully transferred and weighed, in the 572 bottle again, and the spare liquor (if any), is to be put into the narrow graduated tube.

We have then 572 of pure water + the pure water of the salt + the *solid* (or *liquid* matter of the salt whatever it may be), all altogether, in a *liquid* form, in the bottle and the narrow tube.

I was greatly surprized at the results :—if the salt was *anhydrous*, it would all go into the bottle, exactly filling it to a grain ; showing that the salt enters into the *pores* of the water.

If the salt contained *water*, the *quantity* of *water* was measured by the *narrow tube* in all cases whatever, showing that the *solid* matter had in reality entered the *pores* of the water.

To give an instance :—Let 100 grains of Sulphate of Magnesia be taken in its ordinary state, and afterwards made *anhydrous*, by exposing it to a temperature of 4 or 500° of Fahrenheit—then take respectively 200 and 300 grains of the same salt

and expose them to the same high temperature. After they have been made *anhydrous* let each be dissolved separately in 572 grains of pure water, when it will be found that the different solutions remain of the same *bulk* as the water was previously to the salt being dissolved in it, and each solution would fill a bottle capable of containing only 572 grains of pure water. The first solution would consist of 572 grains of water + 52 grains of *solid* matter = 624 grains;—the second solution 572 grains of water + 104 grains of *solid* matter = 676 grains;—and the third 572 grains of water + 156 grains of *solid* matter = 728 grains.

But if the Sulphate of Magnesia was taken in its ordinary state, and 100 grains dissolved in 572 grains of pure water, the *water of crystallization* in the salt would increase the bulk of the water by 48 grain measures, and the solution would consist of 572 + 48 grains of *water* + 52 grains of *solid* matter = 672 grains—a solution of 200 grains of the same salt would consist of 572 + 96 grains of *water* + 104 grains of *solid* matter = 772 grains—and a solution of 300 grains of the salt would consist of 572 + 144 grains of *water* + 156 grains of *solid* matter = 872 grains.

The *solid* matter would go into the *pores* of the water.

It will be remembered, that the *water* and *solid matter* are the same in *bulk* as the *water* itself. This is the reason why the *narrow tube* exactly indicates the *water* of the salt.

Thus, 100 grains of *Sulphate of Magnesia* contains
48 of water, and 52 solid matter.

Thus, 200 grains of *Sulphate of Magnesia* contains
96 of water, and 104 solid matter.

Thus, 300 grains of *Sulphate of Magnesia* contains
144 of water, and 156 solid matter.

And so on in multiple proportions of the water in *bulk*, and the *solid matter* only adds to the *weight*.

I have tried the Carbonates, the Sulphates, the Nitrates, the Murates or Chlorides, the Phosphates, the Arseniates, the Oxalates, the Citrates, the Tartrates, the Acetates, &c. &c. and have been universally successful.—Only the water adds to the *bulk*, and the *solid matter* adds to the *weight*.

The multiplier for *water* is, say 1.000 at 60° temperature; then the multiplier for water and *solid matter* is 1.112 at 60° temperature.

14 QUANTITY OF ACIDS, BASES AND WATER IN SALTS.

Suppose I take *water* of 1000 grains weight, and the *Sulphate of Magnesia* and *water* of 1112 grains weight, they will be of the same *bulk*.

There is a very easy method to ascertain the percentage this way, of the *solid*, in any liquid solution. It is only to lay $\frac{11.2}{100}$ per cent upon it.

To give an example: suppose 572 [of solution give 615 grains weight in 572 bottle and 48 water, &c. to spare, required the *solid* matter?

$$\begin{array}{r}
 572) 615 (1.0752 \\
 \underline{11.2} \\
 1504 \\
 \underline{8272} \\
 .84224 \\
 \underline{\hspace{1.5cm}} \\
 1684480 \\
 \underline{505344} \\
 \text{Solid.....} 52.2 \\
 \text{Liquid} 47.8 \\
 \underline{\hspace{1.5cm}} \\
 100
 \end{array}$$

I take 7 for *ammonia*, instead of 11.2 for the *ammoniacal* salts; but it is only for the *ammonia*, not for the *Sulphates* and *Nitrates*, &c. for the rest, that is the *Sulphates*, &c. 11.2 is used.

Some uncertainty remains in regard to this.

ON A NEW AND EASY METHOD OF ANALYSING SUGAR.

WHEN I published my Table of the relative *weights* of the ultimate particles of gases and other bodies, in October, 1803,* there were 21 I enumerated. *Hydrogen* was 1, the lowest; *Sulphuric Acid* 25.4, was the highest.

These weights were extended to 37 in 1808, in my 1st Edition of Chemistry; and in the part 2nd, in 1810, to 60 in number. In 1827, in my 2nd volume, to 80 in number.

Hydrogen was still 1; the highest was still *Silver* and *Lead*, and *Mercury*; they were 90, the weight of an atom.

One was the standard of *water* for specific gravities, at common temperature: I used to estimate the *solid matter* by fixing a small product upon the *decimal*, of 1.25 I estimated at 27 per cent of *solid*

* Vol. I. *new series*, Manchester Memoirs.

matter ; and 1.50 at 56 per cent ; and in this way I could estimate, with tolerable certainty, for upwards of twenty years, the value of a commodity *in solution with water* in a general way.

In a paper read to this Society, March 31st, 1840, "On the quantity of *Acids, Bases, and Water*, in the different varieties of Salts, with a new method of measuring the *water* of crystallization," I hit upon the mode of taking the *water* and the *salt* separately. The *water* was 572 grains ; the salt was more or less, but it was *exactly* weighed.

I soon found that the *water* of the salt (if any was present) was measured *exactly* by the *narrow* tube. If 20 or 100 grains, more or less, it was 20 or 100 grains, and the bottle was always full besides.

It soon occurred to me, that if an *anhydrous* salt was the subject in solution in 572 water, it would all go into the bottle, *exactly filling it* ; and I found it to be the case in all instances, whether it was 10 grains or 200 grains of *anhydrous* salt, it would go into the bottle, exactly filling it. This fact was new to me, and I suppose to others. It is the greatest *discovery* that I know of next to the atomic theory.

Whether 1, the *weight* of an atom of hydrogen, or 90, the *weight* of an atom of lead, were in proportion to their *weight* or to their *bulk*, I had never made up my mind. Upon the whole I was inclined to think that they were in proportion to their *weights* till within a few months ago ; I am now *decidedly* of opinion that they are in proportion to their *bulks*, as will be demonstrated, I think, by their crystallization ; and it is to be observed, more especially, in the article *Sugar*, which I find is the most *easy* to analyze, and it has been the most *difficult*. Witness the very difficult processes of Dr. Ure and Dr. Prout, with that of 24 tapers burning underneath to equalize the heat.

It is my opinion that the simple atoms are *alike*, *globular*, and all of the same *magnitude* or *bulk*, whether of *hydrogen* 1, or *lead*, 90.

My friend Mr. Ewart, at my suggestion, made me a number of equal balls, about an inch in diameter, about 30 years ago ; they have been in use ever since, I occasionally showing them to my pupils. One ball had 12 holes in it, equidistant ; and 12 pins were stuck in the other balls, so as to arrange the 12 around the one and be in contact with it : they (the 12) were about $\frac{1}{10}$ of an inch asunder. Another ball, with 8 equidistant holes in it : and they (the 8) were

about $\frac{3}{10}$ of an inch asunder, a regular series of equidistant atoms.

The 7 are an awkward number to arrange around 1 atom.

The 6 are an equidistant number of atoms, 90° asunder, 2 at the poles, and 4 at the equator.

The 5 are a *symmetrical* number, 2 at the poles, and 3 at the equator : but the 3 at the equator are 120° asunder, and the 2 at the poles are 90° from the equator.

The 4 is a split of the 8, a regular number and equidistant.

The 3 are around the equator at 120° asunder.

The 2 at two opposite poles, &c.

I had no idea at that time (30 years ago) that the atoms were all of a *bulk*; but for the sake of illustration I had them made alike.

I exposed 100 grains of Sugar for half an hour to a heat of 270° or 300° Fahrenheit : it was begin-

ning to become fluid, about 2 — grains ; but the rest was *solid* and a little browned.

I have a bottle that holds 572 grains of water up to the neck, and a nicely ground stopper, so as to be wiped clean and dry ; this is to be filled with distilled water, and then poured into a convenient glass with a spout to it, that it may be re-conveyed into the bottle again.

One hundred grains of *double refined* Sugar,* carefully weighed, are to be poured into the glass, and stirred about with a very slender stick of glass till it is all dissolved. It is then to be re-conveyed into the bottle, taking care that there is not a drop lost ; a little dexterity is required, but it is easily managed ; the *glass rod* is to be regarded, and the best way is to *stroke* the glass rod till it is clean and dry. Then the remainder is to be poured into the *narrow tube*,† and the number of grains is then read off.

Fifty grains may be used, more or less, of the

* *Double* and *Single* refined are all the same.

† The *narrow tube* is to measure the grains of *water and sugar* overplus, or *water* itself, which is the same *measure*.

Sugar, but 100 grains I mostly used. I generally used 100 grains for the *prime* experiment.

	100 Sugar grains, dissolved in
	572 Water grains
	<hr/>
gave	672 grains by weight.
	<hr/>
In specific gravity Bottle	606 grains
In narrow tube	66 grains
	<hr/>
	672 grains by weight.
	<hr/>

The specific gravity bottle did not vary more than 606 or 607, or 1 grain at most.

It was long known that Sugar was disposed to resolve itself *Solid* and *Liquid*. The *solid* part is *charcoal*, and the *liquid* part is *water*.

Gay-Lussac and *Thenard* had set that matter at rest.

I had the Memoir of *Gay-Lussac* and *Thenard* by me, and did not know, two days ago, that I had it. I was curious to look at it, and to my surprise it was, 42.47 charcoal.

and 57.53 water.

The Memoir was printed in 1811, and I suppose I must have got it at Paris in 1822.

Weight.

I made mine 42.37 charcoal, retaining 5.4 for the weight of an atom,
and 57.73 water, retaining 8 for the weight of an atom.

100

according to my weight in Vol. 2, page 352.

The Memoir alluded to was by burning the charcoal by oxmuriate of potash ; a mode very different from mine, which is much more simple ; but the former was much better than had hitherto been used.

I find 9 *charcoal* atoms,
and 8 *water* atoms are in combination.

That is, 1 *central* atom charcoal ;
and 8 *water* and *charcoal* combined ; that is,
8 triplets.

The way I arrange them is the *only* way they can be arranged, in globular atoms all of a size, or they would interfere with one another.

Central 1 atom of *charcoal*.

8 atoms of *oxygen*, around the central atom, not in contact.

16 atoms of *charcoal* and *hydrogen*, around the *oxygen*,
in contact.

No *contact* between oxygen and oxygen, charcoal and charcoal, and hydrogen and hydrogen, whatever; they having a *repulsion* to each other.

- 100 grains of Sugar in 572 water will be exhibited crystallized; it is very differently crystallized, and yet is the same *weight* as before.
- 100 *East India* Sugar, such as is commonly used; it has a *superabundance* in charcoal $\frac{1}{2}$ grain.
- 100 *West India* Sugar, such as is commonly used; it has also a *superabundance* of charcoal* 1 grain.

Dr. Turner and Dr. William Gregory, (page 914) in their Edition, mentions as *Leibig's* statement,

C 12, H 9, O 9, + 2 aq., that is 16 nearer the *water*, but is still somewhat wide of the truth.

In some modern books we have 12C, H11, O11, which is very near the truth.

Why would not they appeal to the *original authors* in 1811?

* One hundred grains of refined Sugar, after being dissolved in 572 of water, will be exhibited in crystals; it is a very different state of *crystallisation*, after being done in a slow oven of 4 or 500° of heat. It is of 4 or 5 tenths of an inch across in a small circular plate from a centre, very different from what we see in ordinary. It is the same in *weight*, not losing 1 grain; after being kept two or three years it is 100 grains still: I should suppose if it was kept 100 years, it would be of the same weight, not losing a particle.

It is most remarkable that there are 5.4 atoms charcoal; but these are in atomic proportions: for

	charcoal	water		hydrogen.	water.	charcoal.	water.
5.4	:	8	::	43	:	57.	, or
				5.4	:	1	+
						7	::
				43	:	57.	

Now that I have found the *clue* to the theory of this kind of atoms, I have only to follow on the clue methodically.

SUGAR.

- 1 is the central atom of *charcoal*;
- 8 on surrounding it of *oxygen*, *apart* from each other; and
- 16 of *charcoal* and *hydrogen* in contact with each other; and in all 25 atoms to form 1 atom of *Sugar*.

TARTARIC ACID.

- 1 is the central atom of *charcoal*;
- 6 surrounding it of *oxygen*, *apart* from each other;
- 12 of *charcoal* and *hydrogen* in contact with each other; in all 19 atoms to form an atom of *Tartaric Acid*.

ACETIC ACID.

- 1 is the central atom of *charcoal*;
- 4 are surrounding it of *oxygen*, *apart* from each other; and
- 8 of *charcoal* and *hydrogen* in contact with each other; in all 13 atoms to form an atom of *Acetic acid*.

OXALIC ACID.

- 1 is the central atom of *charcoal*; and
- 2 are atoms of *oxygen*, *apart* from each other; and
- 4 are the surrounding atoms of *oxygen* and *hydrogen* in contact with each other. 7 in all the atoms of *Oxalic* acid, and 4 of water.

VINIC ACID.

- 1 is the *central* atom of *charcoal*; *hydrate* of *Water* is the surrounding atom in the *Vinic* acid.

CITRIC ACID.

- 1 is the *central* atom of *charcoal*; (if it may be so called) 1 atom of *water* is attached to it. As *Berzelius* found long ago. Vol. V. 1815, Dr. Thomson's Journal.

The *Experimentum crucis* after all is in the following example :—Take 100 grains of *Sugar*, dissolve it in 100 *water*, which will just melt it (after stirring about awhile with a small glass rod;) then pour it out into a glass *measure* of upwards 160 grains; it will be found 157 grains precisely.

The 57 grains of *pure* water has arisen out of the *Sugar*, and the 43 grains remain in, buried *invisibly* in the *pores* of the water. This follows, as all *solid* bodies remain in *fluids*, adding to the *weight* and not to the *bulk* of them, as I have shewn in my paper, on the Quantity of Acids, Bases and Water in Salts, &c.

